NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

IRRIGATION WATER CONVEYANCE, DITCH AND CANAL LINING, PLAIN CONCRETE

(Ft)

CODE 428A

DEFINITION

A fixed lining of impervious material installed in an existing or newly constructed irrigation field ditch, irrigation canal, or lateral.

PURPOSE

- Improve management of irrigation water
- Prevent water logging of land
- Maintain water quality
- Prevent erosion
- Reduce water loss

CONDITIONS WHERE PRACTICE APPLIES

Ditches and canals to be lined shall serve as integral parts of an irrigation water distribution or conveyance system that has been designed to facilitate the conservation use of soil and water resources on a farm or group of farms.

Water supplies and irrigation deliveries for the area served shall be sufficient to make irrigation practical for the crops to be grown and the irrigation water application methods to be used.

Lined ditches and canals shall be located where they are not susceptible to damage from side drainage flooding, or they shall be protected from such damage.

Plain concrete linings shall be installed only in well-drained soils or on sites where sub-grade drainage facilities are installed with or before the lining. These linings shall not be installed on sites susceptible to severe frost heave or on sites where experience has indicated that the sulfate salt concentration in the soil causes rapid deterioration of concrete.

This standard applies to concrete linings made of non-reinforced Portland cement concrete that is cast in place in a preformed ditch or canal section but does not include linings of pneumatically applied mortar.

This standard is restricted to installations in ditches or canals that have a bottom width less than 6 ft, a design capacity less than 100 ft^3/s, and a maximum velocity of 15 ft/s.

This standard includes design and construction criteria for shaping or reshaping the ditch section as well as for the lining.

CRITERIA

General. Plain concrete linings installed under this practice standard shall be limited to ditches or canals with:

- A bottom width not greater than 6 feet,
- Flow capacity equal to or less than 100 cubic feet per second, and
- Design velocity equal to or less than 15 feet per second.

Materials. On sites where sulfate concentrations exist, concrete linings may be used only if they are made using special sulfate-resistant cement in accordance with those shown in **Table 1**.

Table 1
Types of Cement Required for Concrete Exposed to Sulfate Attack

Water-soluble sulfate (SO_4) percent by weight	Sulfate (as SO_4) in water, parts per million	Cement type ASTM C150 or C595.
0 to <0.10	0 to <150	Any
0.10 to <0.20	150 to <1500	II, IP(MS), IS(MS), P(MS), I(PM)(MS), I(SM)(MS)
0.20 to <2.00	1,500 to <10,000	V
2.0 or more	10,000 or more	V plus pozzolan[1]

Conservation practice standards are reviewed periodically, and updated if needed. To obtain the current version of this standard, contact the Natural Resource Conservation Service.

[1] Pozzolan known or shown to improve sulfate resistance in concrete with Type V cement.

Capacity. A lined ditch or canal shall have enough capacity to meet its requirement as part of the planned irrigation water distribution or conveyance system without damage of overtopping. Design capacity shall be based on the following, whichever is greater;

- Enough capacity to deliver water needed for irrigation to meet design peak consumptive use of crops,
- Enough capacity to provide an adequate irrigation system for all methods of irrigation planned.

For design purposes, the capacity shall be considered to be equal to the capacity as computed with the Manning Formula by using a coefficient of roughness "n" of not less than 0.015.

Velocity. To avoid unstable surge flows, restrict a design velocity in excess of 1.7 times the critical velocity to straight reaches that discharge into ditch sections or structures designed to reduce the velocity to less than critical velocity. Maximum velocity in these straight reaches shall be 15 feet per second.

The velocity in ditch reaches from which water is to be delivered onto the field through gates, turnouts, siphon tubes, or to similar means, shall be less than supercritical and sufficiently low to permit operation of the planned takeout structure or device.

Abrasion potential, caused by heavy sediment must be considered in computing allowable velocity.

Water Surface Elevations. All lined ditches and canals shall be designed so that the water surface elevations at field takeout points are high enough to provide the required flow onto the field surface. If ditch checks or other control structures are to be used to provide the necessary head, the backwater effect must be considered in computing freeboard requirements.

The required elevation of the water surface varies with the type of takeout structure or device used and the amount of water to be delivered through each structure. A minimum head of 0.5 feet shall be provided.

Freeboard. The required freeboard varies according to the ditch or canal, velocity of the water, horizontal and vertical alignment, the amount of the storm or waste water that may be intercepted, and the change in the water surface elevation that may occur when any control structure is operating.

The minimum freeboard for any lined ditch or canal shall be 0.25 feet of lining above the designed water surface.

Minimum freeboard requirement is based on the assumption that the finished channel bottom elevation will vary no more than 0.1 ft from the design elevations. If a construction deviation greater than 0.1 ft is permitted, the minimum freeboard shall be increased.

Additional freeboard shall be provided if required by velocity, depth of flow, alignment, obstruction, curves, and other site conditions.

Ditch or Canal Banks. Ditch and canal banks shall be built up with earth to at least the top edge of the lining. In cut sections, other than in rock, a berm shall be constructed not less than 0.2 feet above the top of the lining. Banks and berms shall be wide enough to ensure stability of fills and to prevent excessive deposition in cut sections.

The minimum top width of the earth embankment supporting the ditch lining shall be 2 feet as measured from the inside face of the top edge of the lining. The side slope of the exposed embankment shall be no steeper than 2 horizontal to 1 vertical.

When a bank or berm is to be used as a roadway, the top width shall be adequate for the purpose. The minimum roadway width shall be 12 feet.

Outside bank slopes and slopes above the berm elevation in cut sections must be flat enough to insure stability. The minimum side slope shall be 2H to 1V.

Ditch or Canal Side Slopes. Plain concrete linings generally are used in ditches and canals that have either a trapezoidal or parabolic cross section.

They may be used in rectangular sections if the sidewall height is not greater than 1½ feet. Side slopes for usual construction methods

shall not be steeper than shown below where H is horizontal and V is vertical:

Hand-placed, formed concrete -
Height of lining less than 1.5 feet - Vertical

Hand-placed, screeded concrete -
Height of lining less than 2½ feet - ¾H to 1V
Height of lining from 2½ to 3 feet – 1H to 1V
Height of lining more than 3 feet - 1¼H to 1V

Slip form concrete -
Height of lining up to 3 feet – 1H to 1V
Height of lining more than 3 feet - 1¼H to 1V

Side Drainage. Control measures to prevent side drainage from entering behind the ditch lining shall be accomplished by one of the following means:

- Inlet structure to the ditch.
- Structure to carry the water over or under the ditch.
- Earth dike constructed next to the ditch to act as a diversion with properly controlled outlets.
- Other effective cutoff devices between the lining and earth bank.

Related Structures. Construction drawings for installing ditch or canal linings shall provide for adequate inlets, outlets, turnouts, checks, crossings, and other related structures needed for successful conservation irrigation. These structures can be installed before, during, or after placement of the lining. They must be constructed or installed in such a way as not to damage the lining or to impair its effectiveness.

All structures shall meet applicable NRCS Conservation Practice Standard requirements for the type of structure used.

Lining Thickness. Thickness of canal linings must be established on the basis of engineering consideration on each job. Location, canal size, velocity, sub-grade conditions, method of construction, operation, and climate shall be evaluated in establishing the thickness to be used. The minimum thickness for non-reinforced concrete linings in rectangular sections shall be 3½ in. For trapezoidal or parabolic sections, the minimum thickness shall be as shown in **Table 2**.

Table 2

Minimum Required Thickness for Plain Concrete Ditch and Canal Linings

Design Velocity[1] ft/s	Minimum Thickness by Climatic Area[2,3,4]	
	Warm in	Cold in
Less than 9.0	1.5	2.0
9.0 - 12.0	2.0	2.5
12.0-15.0	2.5	3.0

[1]Velocities in short chute sections shall not be considered design velocity.
[2]Warm - Average January temperature is 40 °F and above;
Cold - Average January temperature is less than 40 °F.
[3]Up to an additional ½ inch of thickness may be allowed for quantity computations.
[4]Consider soil types when planning thickness of linings.

Lea, Eddy, Chavez, DeBaca, Otero, Sierra, Dona Ana, Luna and Hidalgo Counties, and that portion of Grant County that is south of the White Signal community, are in the warm climate area.

The remainder of the state is in the cold climate area.

CONSIDERATIONS

Energy dissipation should be considered in order to reduce erosion at turnouts.

Capacity should be enough to deliver the water needed for irrigation to meet the design peak consumptive use of the crops in the area served.

Effects on the water budget, especially on volumes and rates of runoff, infiltration, evaporation, transpiration, and deep percolation and ground water recharge.

Effects on downstream flows or aquifers that would affect other water uses or users.

Potential use for irrigation water management.

Potential changes in growth and transpiration of vegetation located next to the conveyance because of the elimination of leakage from the system.

Effects of installing the lining on the erosion of the earth conveyance and the movement of

sediment and soluble and sediment-attached substances carried by water.

Effects on the movement of dissolved substances to ground water.

Effects on wetlands or water-related wildlife habitats.

Effects on the visual quality of water resources.

Consider energy dissipation devices for siphon tubes and turnouts to reduce erosion.

Consider the addition of fiber reinforcement to increase durability and reduce the potential for minor cracking.

DRAWINGS AND SPECIFICATIONS

Drawings and specifications for installing non-reinforced concrete irrigation ditch and canal linings shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

OPERATION AND MAINTENANCE

An Operation and Maintenance (O&M) plan shall be developed for plain concrete irrigation ditch and canal linings. The plan should document the actions needed to ensure that practices perform adequately throughout their expected life.

The O&M plan should address, as a minimum, sediment/debris removal, exclusion of livestock, embankment integrity, repair or replacement of cracked or broken canal sections, and replacement of deteriorated linings.